Hibiscus elatus Sw. Mahoe

SO-ITF-SM-14

Malvacae Mallow Family

Peter L. Weaver and John K. Francis

HABITAT

Native Range

Hibiscus elatus Sw., commonly known as mahoe, is reported as growing naturally only in Cuba and Jamaica (fig. 1), where it is found in moist, upland areas *(2, 3, 17, 18, 25)*. There is indirect evidence for an even more restricted natural range, with Cuba suggested as the place of origin, and mahoe being introduced into Jamaica rather than originating there *(2)*. Mahoe has also been established in plantations on both islands, and has become naturalized in southern Florida, Mexico, Peru, Brazil, and throughout the West Indies *(6, 14)*. Mahoe was first introduced into Puerto Rico in the mid-1940's *(31)* and was subsequently tested in species' adaptability trails in humid areas on the island *(8)*. It has also been successfully introduced into Hawaii *(35)*.

Climate

Mahoe grows naturally in humid forests. In Cuba, it was recorded in "monte fresco," or humid montane forest, in the eastern Oriente province at elevations between 150 and 1000 m *(25)*. Temperatures in this area range between 20 and 25 °C, with rainfall ≥ 1500 mm/yr *(1)*. Frost is unknown in the natural range.

In Jamaica, mahoe is found in upland areas where rainfall is between 1800 and 3800 mm/yr. However, on alluvial plains it survives with rainfall ≤1000 mm/yr *(11, 27)*. At most lower elevations, the critical average annual rainfall appears to be about 1150 mm/yr *(2)*. In Puerto Rico, mahoe was planted on sites with rainfall between 1500 and 3000 mm/yr *(8)*, areas that correspond to subtropical moist, subtropical wet, and lower montane wet forests *(7)* in the Holdridge life zone system *(13)*.

Soils and Topography

In Cuba, mahoe grows on soils derived from igneous rocks *(25)*. The soils are leached, acidic, red clays *(1)*. In Jamaica, mahoe is found on moist soils derived from limestone at 150-m elevation and on residual soils over shales and volcanic rock to over 1200 m in elevation *(26, 27)*.

Mahoe is adapted to a wide range of sites in Puerto Rico. It develops satisfactorily on tropohumults and tropoudalfs with textures ranging from clays to sandy loams and with pH values between 4.3 and 7.6 *(8)*. Mahoe was one of several species suggested for planting on 60,000 ha of sandy, well-drained granitic uplands, with rainfall between 1650 and 2500 mm/yr *(9)*.

Associated Forest Cover

In the monte fresco of Cuba, mahoe grows in association with other hardwood species such as *Andira inermis* (Sw.) H.B.K., *Calophyllum brasilense* var. *antillanum* Standley, *Carapa guianensis* Aubl., *Guarea guara* (Jacq.). P. Wils., *Manilkara sideroxylon* (Hook.) Dub., *Oxandra laurifolia* (Sw.) A. Rich., *Pithecellobium arboreum* (L.) Urb., *Terminalia intermedia* (Rich.) Urb., and *Prunus* sp., and with the palm species *Bactris cubensis* and *Calyptrogne* sp. *(25)*. In Jamaica, mahoe has been planted in many areas. However, it has not been positively identified as growing naturally in association with other native woodland species outside forest plantations or nurseries *(2)*. *Calophyllum calaba* has been observed as a component of natural stands in areas where planted mahoe grows well *(2)*.

LIFE HISTORY

The mature mahoe tree can be identified by its long-stalked, heart-shaped leaves and large funnel-shaped "hibiscus" flowers. It is a medium-sized evergreen tree (fig. 2) that can grow to 25 m tall with a straight trunk 35 cm or larger in diameter *(18)*.

Reproduction and Early Growth

Flowering and Fruiting.—Flowers are borne one to three at a time on stout green stalks at leaf bases at the

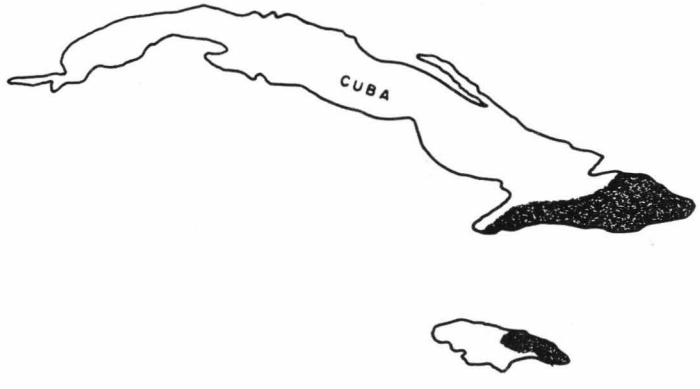

Figure 1.—*Natural distribution of* Hibiscus elatus *in the Caribbean.*

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ends of twigs. The calyx is light green, and the corolla, consisting of five spreading elliptic petals, is yellow, orange, or red bronze, darkening with age. Many stamens are mounted on a pinkish column with the corolla at the base. The pistil inside the stamen column has a five-celled ovary, a long style, and five rounded stigmas. Flowering is irregular throughout the year *(18)*.

Seed Production and Dissemination.—Numerous short hairy seeds are borne in elliptic seed capsules. When mature, the capsules dry and split on the tree, and the seeds are dispersed, probably within a week, in the vicinity of the parent tree. In Jamaica, seeds ripen in March and April; mature capsules are then picked and laid in the sun to open *(27)*. Capsules are later separated from the seeds by crushing and shaking. Seed weight averages 1.8 to 1.9 g per 100 seeds. Germination reported in 1940 for Jamaica was comparatively high, averaging 80 percent after seed collection, remaining fairly high for 4 months, and then declining after 6 months *(27)*. In contrast, seed dormancy in Cuba has been reported to be one of the principal problems affecting the propagation of mahoe *(19)*. Seeds appeared dormant when they were disseminated, a condition that apparently varied according to environmental conditions. Dormancy was reported to decline in June of the year of seed harvest *(19)*.

Figure 2.—Hibiscus elatus *Sw. (mahoe) in a plantation. Note mahoe regeneration in the foreground.*

In Puerto Rico, 34 mahoe plantation sites were surveyed, and in 1987 flowering and seed production were observed on all of them *(8)*. Mahoe seed capsules were collected when mature and dried in a solar drier until they opened. Seeds were removed, weighed, and refrigerated in sealed plastic bottles for a month; they were then sown in moist sand or on the surface of moist peat. Mahoe germination after 2 weeks averaged 6 percent on sand and zero on peat *(8)*. Between 2 and 4 months, an additional 14 percent germinated on sand. Seed weight was 2.1 g per 100 seeds.

Seedling Development.—In Jamaica, despite ample seed production, the potential for unaided regeneration of mahoe was considered low. Outside forest nurseries, seedlings and saplings were scarce *(2)*. In Puerto Rico, reproduction of planted mahoe was observed on numerous sites even in medium dense shade under closed mahoe stands *(8)*. Seedlings and saplings were absent from plots ≤6.5 years old and present on plots ≥16 years old, with few exceptions. Drought was suggested as a limiting factor for growth on well-drained sites where rainfall ≤1500 mm/yr.

In Jamaica, seeds were sown in nurseries and seedlings were transplanted to the field when about 1 year old. At that time, the seedlings ranged in size from 45 to 60 cm tall *(27)*. Removing the leaves at the time of planting was a recommended practice. After planting, the leading shoot often died back a few centimeters and was then replaced by an auxiliary shoot. Rapid growth usually began about 6 months after outplanting. In Puerto Rico, a limited planting program is now sustained by collecting small wildings from under plantations, growing them in nursery bags under shade for a few weeks, and then outplanting. In Cuba, seedling growth was enhanced by fertilization with nitrogen and phosphorus *(12)*.

Vegetative Reproduction.—Mahoe may be reproduced from woody cuttings of seedlings and small saplings. The cuttings should be about 45 cm long, 5 to 15 mm thick, and buried two-thirds of their length in moist soil under light shade in the field or nursery. About 50 percent will root within 3 months. Seedlings, saplings, and small pole-sized mahoe coppice readily. Epicormic sprouting also occurs in mahoe. This condition and adventitious rooting around basal wounds appear more common in wet areas.

Sapling and Pole Stage to Maturity

Growth and Yield.—A survey of the 34 mahoe plantation plots in Puerto Rico showed that stands between 6.5 and 8.5 years old had volumes from 90 to 154 m^3/ha with a mean annual volume increment (MAVI) between 14.4 and 23.7 m^3/ha/yr (8). For plantings from 16 to 27 years old, the volume of mahoe ranged from 97 to 979 m^3/ha. On the latter plots, MAVI showed more variation and ranged from 6.0 to 30.5 m^3/ha/yr for plots between 16 to 21 years old and from 4.5 to 36.0 m^3/ha/yr for plots 24 to 27 years old (fig. 3).

Mean diameters (d.b.h.) for mahoe between 6.5 and 8.5 years old were between 10.0 and 21.4 cm (table 1). These

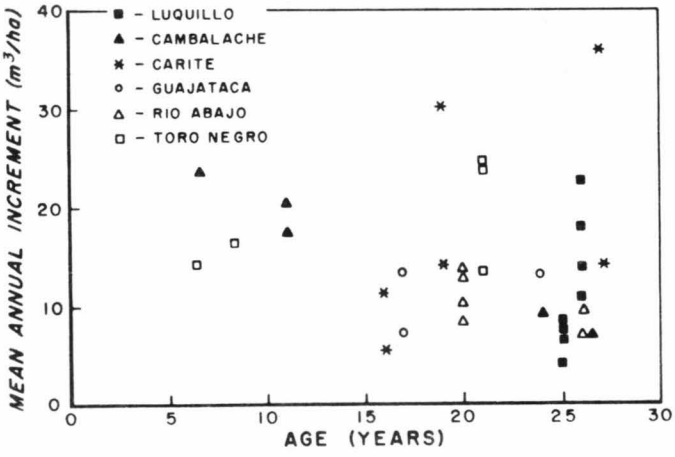

Figure 3.—*Volume growth of* Hibiscus elatus *in several plantations in Puerto Rico.*

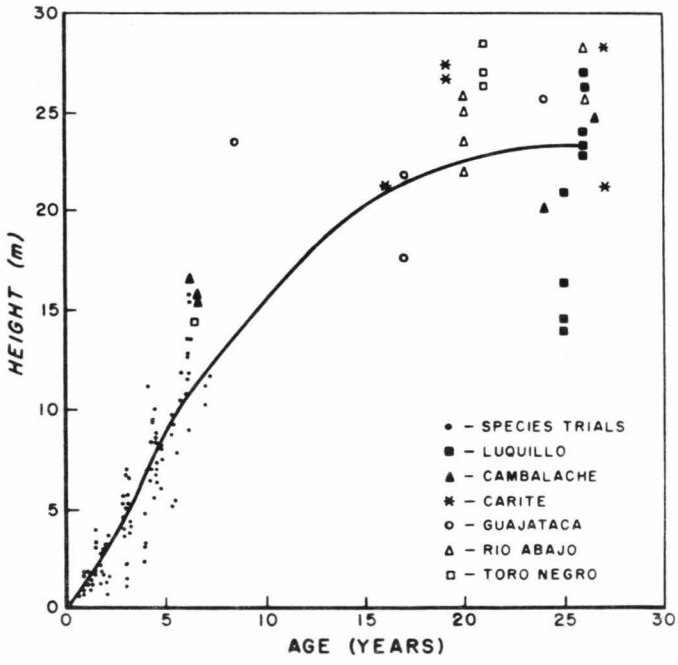

Figure 4.—*Height growth of* Hibiscus elatus *in several plantings in Puerto Rico.*

data correspond to mean annual diameter increments (MADI) of 1.52 and 2.52 cm/yr. Mean heights for these same stands ranged from 11.9 to 21.9 m, and mean annual height increment (MAHI) ranged from 1.8 to 2.6 m/yr. In each instance, the best growth rates were attained in an 8.5-year-old thinned stand.

For stands between 16 and 21 years old, mean diameters ranged from 11.5 to 25.8 cm and mean heights from 15 to 25.0 cm. These data correspond to MADI's between 0.64 and 1.23 cm/yr and MAHI's between 0.7 and 1.3 m/yr. For the oldest stands, those between 24 and 27 years old, mean diameters varied from 15.4 to 44.6 cm and mean heights from 13.4 to 24.7 m. These data correspond to MADI's between 0.68 and 1.68 cm/yr and MAHI's between 0.5 and 1.0 m/yr. The greatest values in both diameter and height were for a stand situated in a valley surrounded by limestone hills.

The analysis of height growth using information from all plantings and adaptability trials in Puerto Rico yielded the relationship:

$$H = -0.41\,X^{1.5} + 3.06\,X - 2.04 \quad (r^2 = 0.9)$$

where H equals height in meters and X = age in years (fig. 4). Considerable variation in height is evident at any age. Success with mahoe in Puerto Rico led to the establishment of 22 ha of mahoe plantations among the limestone hills of Rio Abajo Forest where sawtimber volume averages 128 m^3/ha *(5)*.

Comparative growth information for mahoe from other areas is shown in table 2. In Caribbean locations, where it is a favored plantation species, MADI ranges from 0.9 to 3 cm/yr and MAHI between 0.9 and 2.1 m/yr. In Hawaii, the early results of species' adaptability trials showed good survival on six different sites, but height growth was slower than in Puerto Rico *(35)*. Mahoe was judged as promising on five of the seven Hawaiian sites where it was tested.

Rooting Habit.—Seedlings produce a taproot that appears to be replaced later by a lateral root system. Seedling roots are notably fleshy. Although older trees do not usually buttress, they often swell near the surface roots. This growth habit could damage sidewalks and curbs, especially on poorly aerated soils. Lateral roots near the soil surface occasionally develop suckers, a condition that appears more common in wet areas.

Reaction to Competition.—Mahoe is able to grow in densely planted stands. In St. Lucia of the Lesser Antilles, trees are established in 1.8- by 1.8-m spacings *(34)*. In Puerto Rico, the 34 plantings of mahoe throughout the humid areas of the island contained between 300 and 2,170 stems per ha *(8)*. Total basal areas for these stands ranged from 20 to 77 m^2/ha for plantings between 17 and 27 years old. Crown-to-bole ratios for 80 trees sampled in these stands averaged 20.3±0.7.

The initial spacing of mahoe should be relatively dense, probably 2 by 2 m. After 4 to 5 years, depending on the growth rate, the stand should be thinned to a spacing of about 4 by 4 m.

Damaging Agents.—Mahoe appears relatively free of plant pests and diseases, with only occasional reports of damage. In Jamaica, leaf spots caused by *Septoria* sp. and *Pestalstia heterocornis* Guba have been observed *(16)*, and unconfirmed reports of heartrot in thinned mahoe plantations have been mentioned *(22)*. Moreover, trees are sometimes infested by cotton stainer bugs, and ants are suspected of using seeds that have fallen on the ground for food *(2)*. In Puerto Rico, a dieback characterized by crown branching, leaf wilt, and blackening of the trunk was observed in the earliest plantations *(31)*. The casual agent was unknown, and further damage has not been reported. Today, immature seeds in Puerto Rico are quite frequently consumed while still on the tree, probably by bats.

When used in construction, mahoe is highly resistant to attack by decay fungi *(6)*. No data could be found on its resistance to termite attack; however, the closely related species *H. tiliaceous* was found to be susceptible to attack by the dry-wood termite *Cryptotermes brevis* Walker *(36)*.

Epicormic branching has been reported in mahoe even with plantings as dense as 1.8 by 1.8 m *(27)*. Pruning and

Table 1.—*Estimates of diameter and height growth for* Hibiscus elatus *(mahoe) plantations in Puerto Rico*

Forest site	Age	Growth of all mahoe (Mean ± SE)		Growth of dominant mahoe (Mean)		
		D.b.h.	Height	D.b.h.	Height	Clear bole
	Years	*cm*	*m*	*cm*	*m*	
Luquillo						
Caracoles						
1	25	17.3 ± 1.82	13.4 ± 0.41	22.5	14.3	3.5
2	25	17.8 ± 1.25	13.4 ± 0.38	22.6	14.7	3.7
3	25	17.9 ± 2.38	13.8 ± 0.84	28.2	16.5	5.3
4	25	16.9 ± 5.25	14.9 ± 2.10	50.7	21.0	1.0
Sabana						
1	26	19.7 ± 2.11	17.9 ± 1.21	28.9	24.2	9.6
2	26	18.1 ± 2.86	16.2 ± 1.42	32.2	23.0	1.8
3	26	21.7 ± 2.51	19.7 ± 1.32	35.3	27.0	4.0
4	26	20.4 ± 2.14	20.1 ± 1.09	34.5	26.4	6.3
Arboretum	26	25.6 ± 2.14	20.4 ± 0.55	36.3	23.4	5.9
Cambalache						
1	6.5	11.0 ± 0.55	13.2 ± 0.45	15.4	16.6	4.8
2	6.5	10.8 ± 0.48	13.3 ± 0.40	13.7	15.8	3.4
3	6.5	10.0 ± 0.44	13.4 ± 0.43	12.4	15.6	3.4
4	24	22.9 ± 2.22	18.5 ± 1.12	27.4	20.0	5.4
5	26.5	44.6 ± 2.06	24.7 ± 1.36	44.6	24.7	3.3
Carite						
1	27	27.9 ± 3.03	24.2 ± 1.05	41.8	28.2	7.9
2	27	16.9 ± 3.06	20.2 ± 0.56	31.9	21.4	2.7
3	16	19.2 ± 1.98	17.0 ± 1.10	28.6	21.3	3.0
4	16	19.4 ± 3.01	15.0 ± 1.09	...	...	...
5	19	20.6 ± 3.36	25.0 ± 1.62	30.2	26.9	3.2
6	19	19.3 ± 2.32	23.6 ± 1.11	32.7	27.3	4.7
Guajataca						
1	17	15.0 ± 0.91	19.3 ± 0.84	18.5	21.7	4.3
2	17	11.5 ± 0.80	15.5 ± 0.54	15.8	17.6	3.5
3	24	15.4 ± 2.65	16.4 ± 1.74	33.4	25.6	5.1
4	8.5	21.4 ± 2.12	21.9 ± 1.96	23.4	23.6	6.5
Rio Abajo						
1	20	12.7 ± 5.39	18.9 ± 5.21	19.8	25.0	4.4
2	20	14.6 ± 8.62	18.6 ± 5.93	25.1	25.8	11.2
3	20	13.1 ± 6.80	17.6 ± 5.82	21.2	23.5	6.6
4	26	18.0 ± 4.16	18.0 ± 2.20	39.5	25.8	1.2
5	26	31.4 ± 5.67	25.1 ± 3.28	36.7	28.2	3.6
6	20	14.0 ± 0.98	18.2 ± 0.86	20.5	23.9	7.9
Toro Negro						
1	21	21.0 ± 2.55	20.2 ± 1.74	32.4	27.0	12.0
2	21	25.8 ± 1.81	24.2 ± 1.38	31.2	28.5	9.5
3	21	15.1 ± 2.55	18.3 ± 1.88	30.0	26.5	6.8
4	6.5	11.4 ± 0.69	11.9 ± 0.37	16.1	14.4	1.9

Table 2.—*Comparative growth data for* Hibiscus elatus *from previously published sources.*[1]

Location (source)	Age	Elevation	Rainfall	Stems per hectare	Basal area	Dominant mahoe	
						D.b.h.	Height[2]
	Years	*m*	*mm/yr*	*Number*	*m^2/ha*	*cm*	*m*
Hawaii	5	30	2500	...	...	...	>5 (15)
(35)	5	640	2800	...	...	...	>3 (7)
	5.5	870	5330	...	...	...	>3 (9)
	6.6	130	4450	...	...	...	>3 (8)
	5	50	2540	...	...	...	>1 (2)
	5.8	240	2950	...	...	...	>5 (10)
Jamaica	16	300	...	...	16	21	31
(27, 32)	8	1150	5080	1680	...	24	14
	15	1150	5080	...	...	30	18
	6	460	3050	1120	20	18	9
	17	300	1020	...	...	31	>21
Puerto Rico	6	150	2030	...	...	...	15
(31, 32)	10	800	2540	800	20	20	18
	11	200	2040	500	...	23	23
St. Lucia	7	20	3000	...	11	14	21
(34)	18	...	...	...	17	17	17
	19	...	...	...	23	19	19

[1]Italicized numeral within parentheses refers to the reference listed in the Literature Cited section.
[2]Tallest trees in parentheses.

wider spacings may overcome this problem if the expense can be justified. Otherwise, the tall, straight, multiple stems developing from epicormic branches on the lower bole can be used as poles, posts, and pulpwood. Although epicormic sprouting appears more common in wet areas, the problem is neither consistent in such areas nor well understood at this time.

The earliest descriptions of mahoe indicated that it was intolerant of exposed conditions and that it was susceptible to wind damage *(27)*. More recent observations confirm this. In the Puerto Rican hurricane of 1956 *(33)* and the Jamaican hurricane of 1980 *(30)*, mahoe was found to be windfirm but susceptible to limb breakage. Moreover, form defects, mainly sweep, were found on all but 1 of the 34 plots sampled in Puerto Rico. The trees affected varied from 6 to 79 percent of the trees sampled on the respective plots *(8)*.

SPECIAL USES

Mahoe is a high-grade furniture wood prized for heartwood, richly variegated with shades of purple, metallic blue, and olive green *(6, 20, 23, 24, 28, 29)*. The specific gravity of mahoe averaged 0.50 g/cm^3 in Puerto Rico *(8)*, showing slightly higher values in drier areas *(8, 15)*. The timber is also suitable for turnery, flooring, framing, building construction, boat building, agricultural implements, and for use as railway sleepers *(18, 20, 21)*. In the past, the inner bark was used for making rope and cord that was very durable in salt and brackish water *(20)*.

In addition to its value as a timber species, mahoe has been used for windbreaks in Cuba, despite its tendency to loose leaves during dry spells *(10)*. Mahoe, based on casual observation, is generally reported to be durable to very durable *(4, 28)*, but no tests have been completed to verify this information *(6, 20)*.

GENETICS

Mahoe and sea hibiscus (*H. tileaceous* L.) are closely related *(17)* and some authors include them under the older name, *H. tileaceous (2)*. Indeed, the traits used to separate natural populations in the West Indies are not reliable. Similarity between the species has led to speculation that mahoe evolved from sea hibiscus or an ancestor common to both.

Ecologically, mahoe is an upland species, and sea hibiscus occurs along the coast. Moreover, mahoe is usually a tall, straight tree with superior wood properties, and light branching throughout the crown. Sea hibiscus is a scrubby tree with soft wood that lacks durability. Its branches are decumbent and root in contact with the soil. The tendency of mahoe to form epicormic branches probably had its origin with sea hibiscus or an ancestor common to both species.

Hybrids apparently exist *(2)*. At a 335-m elevation near Phoenix Park in St. Ann's parish, Jamaica, a population with characteristics intermediate between the two species was observed. Of several flowers that were examined, the anthers were empty of pollen and a very small number of capsules with very few seeds in them were formed.

Hybridization and the resulting heterozygosity could cause a gradual loss of mahoe's valuable wood character-

istics *(2)*. This could be avoided by establishing mahoe plantations in isolation as sources of pure seed. Epicormic sprouting, a tendency that may be inherited, could become one trait for subsequent genetic selection.

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